

REMARKS

Summary of the Office Action

In the Office Action dated November 7, 2002, claims 2 and 6 are objected to allegedly because the term “DCS” should be replaced by the full term. Claims 1-9 stand rejected under 35 U.S.C. § 112, first paragraph, as allegedly containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. Claims 4 and 5 stand rejected under 35 U.S.C. § 112, first paragraph, allegedly because of missing units. Claim 9 stands rejected under 35 U.S.C. § 112, first paragraph, allegedly because it is questioned whether the ratio recited at line 2 is the ratio of thickness between the polysilicon film and the undoped polysilicon film. Claims 1-9 stand rejected under 35 U.S.C. § 112, second paragraph, as allegedly being indefinite for failing to particularly point out and distinctly claim the subject matter which applicants regard as the invention. Claims 1-2 and 4-6 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over U.S. Patent No. 5,619,052 to Chang et al. (hereinafter “Chang”) in combination with U.S. Patent No. 5,866,474 to Liu (hereinafter “Liu”) and pages 440-441 of “Silicon Processing for the VLSI Era, Volume 1” by S.W. Wolf and R.N. Tauber, published by Lattice Press (hereinafter “Wolf”). Claims 3 and 7 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Chang in combination with Liu and Wolf as applied to claims 1, 2, and 4-6 above. Claims 8 and 9 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Chang in combination with Liu and Wolf as applied to claims 1, 2, and 4-6 above, and in further view of U.S. Patent No. 6,096,630 to Byun et al. (hereinafter “Byun”).

Summary of the Response to the Office Action

Applicants have amended claim 2 at line 2 and claim 6 at line 2 to recite --

DiChloroSilane gas-- rather than “DCS gas” in accordance with the comments of the Office Action. Applicants have amended claim 1 at line 12 to recite --forming an upper oxide film on the nitride film-- rather than “forming an upper oxide film on the semiconductor substrate.”

Applicants respectfully traverse the rejections of claims 4 and 5 under 35 U.S.C. § 112, first paragraph. Applicants have amended claim 9 to recite --the polysilicon film and the undoped polysilicon film are deposited at a ratio of thickness of 4:1-7:1-- rather than “the polysilicon film and the undoped polysilicon film are deposited at a ratio of 4:1-7:1.” Applicants have amended claims 1 and 4, the abstract and the specification to address the rejections under 35 U.S.C. § 112, first paragraph, and in accordance with the comments of the Office Action. Applicants traverse the rejections of claims 1-9 under 35 U.S.C. § 103(a). Applicants have added independent claim 10 to differently describe the subject matter of the instant invention. Accordingly, claims 1-10 are presently pending in this application.

The Objections to Claims 2 and 6

Claims 2 and 6 are objected to allegedly because the term “DCS” should be replaced by the full term. Applicants have amended claim 2 at line 2 and claim 6 at line 2 to recite --

DiChloroSilane gas-- rather than “DCS gas” in accordance with the comments of the Office Action. Accordingly, Applicants respectfully request that the objections to claims 2 and 6 be withdrawn.

The Rejections of Claims 1-9 under 35 U.S.C. § 112, first paragraph

Claims 1-9 stand rejected under 35 U.S.C. § 112, first paragraph, as allegedly containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention.

Applicants have amended claim 1 to differently describe the invention and to address the concerns of the Office Action. Specifically, Applicants have amended claim 1 at line 12 to recite --forming an upper oxide film on the nitride film-- rather than “forming an upper oxide film on the semiconductor substrate.” Applicants respectfully submit that this amendment is fully supported by the disclosure in the original application as depicted at least in Figure 1D and as recited at least at page 7, lines 3-17 of the specification. Applicants assert that claims 1-9, as amended, fully comply with the requirements of 35 U.S.C. § 112, first paragraph. Accordingly, Applicants respectfully request that the rejections of claims 1-9 under 35 U.S.C. § 112, first paragraph, be withdrawn.

The Rejections of Claims 4-5 under 35 U.S.C. § 112, first paragraph

Claims 4 and 5 stand rejected under 35 U.S.C. § 112, first paragraph, allegedly because of missing units. Applicants respectfully traverse this rejection of claims 4 and 5 under 35 U.S.C. § 112, first paragraph, for the following reasons.

The Examiner asserts at Section 4 of the Office Action that units are missing in claim 4, line 2 and claim 5, line 2. Applicants respectfully submit that the units in question appear respectively in claims 4 and 5 as recited in the Preliminary Amendment filed by Applicants on

December 7, 2001. In the Preliminary Amendment filed on December 7, 2001, claim 4, line 2 recites “introducing one of N₂O and NO of 1-20ℓ into a furnace,” and claim 5, line 2 recites “introducing the oxygen gas of 5-20ℓ into a furnace.”

In view of the foregoing, Applicants respectfully submit that claims 4-5, as submitted in the Preliminary Amendment filed on December 7, 2001, fully comply with the requirements of 35 U.S.C. § 112, first paragraph. Accordingly, Applicants respectfully request that the rejection of claims 4-5 under 35 U.S.C. § 112, first paragraph, be withdrawn.

The Rejection of Claim 9 under 35 U.S.C. § 112, first paragraph

Claim 9 stands rejected under 35 U.S.C. § 112, first paragraph, allegedly because it is questioned whether the ratio recited at line 2 is the ratio of thickness between the polysilicon film and the undoped polysilicon film.

Applicants have amended claim 9 to recite --the polysilicon film and the undoped polysilicon film are deposited at a ratio of thickness of 4:1-7:1-- rather than “the polysilicon film and the undoped polysilicon film are deposited at a ratio of 4:1-7:1.” Applicants respectfully submit that this amendment is fully supported by the disclosure in the original application as recited at least from page 7, line 22 to page 8, line 5 of the specification. Applicants submit that claim 9, as amended, fully complies with the requirements of 35 U.S.C. § 112, first paragraph. Accordingly, Applicants respectfully request that the rejection of claim 9 under 35 U.S.C. § 112, first paragraph, be withdrawn.

The Rejections of Claims 1-9 under 35 U.S.C. § 112, second paragraph

Claims 1-9 stand rejected under 35 U.S.C. § 112, second paragraph, as allegedly being indefinite for failing to particularly point out and distinctly claim the subject matter which applicants regard as the invention.

Applicants have amended claims 1 and 4, the abstract and the specification in accordance with the Examiner's helpful suggestions in the Office Action. Specifically, Applicants have amended the abstract, the paragraph beginning at page 3, line 6 of the specification, the paragraph beginning at page 6, line 11 of the specification, the paragraph beginning at page 7, line 3 of the specification, and claims 1 and 4 by replacing all occurrences of "nitrogen layer" to recite --nitrogen-containing layer--. Applicants respectfully submit that this amendment is fully supported by the disclosure in the original application as recited at least at the paragraph beginning at page 6, line 11 of the specification. Applicants submit that claims 1-9, as amended, fully comply with the requirements of 35 U.S.C. § 112, second paragraph. Accordingly, Applicants respectfully request that the rejections of claims 1-9 under 35 U.S.C. § 112, second paragraph, be withdrawn.

The Rejections under 35 U.S.C. § 103(a)

Claims 1-2 and 4-6 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Chang in combination with Liu and Wolf. Claims 3 and 7 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Chang in combination with Liu and Wolf as applied to claims 1, 2, and 4-6 above. Claims 8 and 9 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Chang in combination with Liu and Wolf as applied to claims 1, 2, and 4-6 above, and in further view of Byun.

Applicants traverse the rejections of claims 1-9 under 35 U.S.C. § 103(a) for at least the following reasons.

Applicants have amended independent claim 1, as discussed above, to correct informalities indicated by the Office Action but not to distinguish over any prior art.

Independent claim 1, as amended above, recites a method of manufacturing a flash memory device that includes:

etching the first polysilicon film and a first portion region of the tunnel oxide film; forming a lower oxide film on the semiconductor substrate; performing a nitrification process to form a nitrogen-containing layer below the lower oxide film; performing an annealing process using an oxygen gas so that the nitrogen-containing layer is transferred to a surface of the lower oxide film, thus forming a nitride film.

The Office Action concedes at page 4 that Chang does not teach the steps of claim 1 recited above. Nevertheless, the Office Action asserts at page 4 that Liu teaches these steps at column 1, lines 38-50 and Figure 1A. The Office Action further asserts that it “would have been within the scope to one [of] ordinary skill in the art to combine both teachings because it would enable formation of lower oxide film 64 and nitride layer 64 of Chang et al. to be performed.”

Applicants respectfully submit that Liu does not teach at least the steps of claim 1 recited above. As depicted in Figures 1A and 1B, and as recited at column 1, lines 34 to 50 of Liu:

As shown in FIG. 1A, a silicon substrate 10 is first provided. The substrate 10 is placed inside an oxidation furnace, and then oxygen is passed. Next, a preoxidation process is performed by heating the furnace to a temperature of about 750°-850°C. to form a first oxide layer 11 on the substrate 10. Thereafter, the substrate 10 is placed inside an oxidation furnace, and then either nitrous oxide or nitric oxide is passed. In a subsequent step, heating is carried out at a temperature of about 750°-850°C. to form a barrier layer 12 at the interface between the first oxide layer 11 and the substrate 10. The barrier layer 12 can be an oxynitride layer.

Next, in FIG. 1B, the substrate 10 is once again placed inside an oxidation furnace and oxygen is passed. Then, a reoxidation process is carried out at a

temperature of about 750°-850°C. to form a second oxide layer 13 at the interface between the barrier layer 12 and the substrate 10 (emphasis added).”

Applicants respectfully submit that the first oxide layer 11 of Liu is the upper oxide layer. The barrier layer 12 of Liu is subsequently formed below the upper oxide layer. The lower layer 13 of Liu is subsequently formed below the barrier layer 12. However, in the instant invention as recited in claim 1, “the nitrogen-containing layer is transferred to a surface of the lower oxide film” by an annealing process and the upper oxide film is formed on the nitride film. Moreover, Applicants respectfully assert that Wolf does not teach the features of independent claim 1 recited above. Accordingly, Applicants submit that Wolf, Liu and Byun, whether taken singly or in combination, fail to cure the deficiencies of Chang as applied to independent claim 1.

Accordingly, Applicants respectfully assert that Chang, Liu, and Wolf, whether taken singly or in combination, do not teach or suggest each feature of independent claim 1. As pointed out in MPEP § 2143.03, “[to] establish prima facie obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. In re Royka, 490 F.2d 981, 180 USPQ 580 (CCPA 1974).” Thus, Applicants respectfully submit that independent claim 1 is in condition for allowance as not being unpatentable over Chang in combination with Liu and Wolf. Accordingly, Applicants respectfully request that the rejection of claim 1 under 35 U.S.C. 103(a) be withdrawn.

Furthermore, Applicants respectfully submit that dependent claims 2-9 should be allowed at least because of their respective dependence upon allowable claim 1. Accordingly Applicants respectfully request that the rejections of dependent claims 2-9 under 35 U.S.C. 103(a) be withdrawn.

The Addition of Independent claim 10

Applicants have added independent claim 10 to differently describe the subject matter of the instant invention. Accordingly, claims 1-10 are presently pending in this application.

Applicants respectfully submit that newly added claim 10 is fully supported in the original specification at least by the recitation beginning at page 6, line 11 and ending at page 9, line 1. Applicants respectfully submit that claim 10 is allowable over the currently-applied art.

Conclusion:

In view of the foregoing, Applicants respectfully request reconsideration and reexamination of this application, withdrawal of all rejections and objections, and the timely allowance of all pending claims. Should the Examiner feel that there are any issues outstanding after consideration of this response, the Examiner is invited to contact Applicants' undersigned representative to expedite prosecution.

Attached hereto is a marked-up version of the changes made by the current amendment. The attachment is captioned "**VERSION WITH MARKINGS TO SHOW CHANGES MADE.**"


If there are any other fees due in connection with the filing of this response, please charge the fees to our Deposit Account No. 50-0310. If a fee is required for an extension of time under 37 C.R.R. § 1.136 not accounted for above, such an extension is requested and the fee should also be charged to our Deposit Account.

Respectfully submitted,

MORGAN, LEWIS & BOCKIUS LLP

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By:


Paul A. Fournier
Registration No. 41,023

Customer No. 09629
MORGAN, LEWIS & BOCKIUS LLP
1111 Pennsylvania Avenue, N.W.
Washington, D.C. 20004
Telephone: (202) 739-3000
Facsimile: (202) 739-3001

VERSION WITH MARKINGS TO SHOW CHANGES MADE**IN THE ABSTRACT:**

The abstract has been amended as follows:

-- The present invention relates to a method of manufacturing a flash memory device. In case of forming a dielectric film consisting of a lower oxide film, a nitride film and upper oxide film that is formed between a floating gate and a control gate, a nitrification process is performed after the lower oxide film is formed, thus forming a nitrogen-containing layer below the lower oxide film. Then, an annealing process using an oxygen gas is performed to move the nitrogen-containing layer onto the surface of the lower oxide film, thus forming a nitride film. Therefore, the present invention can reduce the effective thickness of the dielectric film.--

IN THE SPECIFICATION:

The specification has been amended as follows:

The paragraph beginning at page 3, line 6 has been replaced with the following paragraph:

-- In order to accomplish the above object, a method of manufacturing a flash memory device according to the present invention is characterized in that it comprises the steps of sequentially forming a tunnel oxide film and a first polysilicon film on a semiconductor substrate and then etching the first polysilicon film and a given region of the tunnel oxide film; forming a lower oxide film on the entire structure; performing a nitrification process to form a nitrogen-containing layer below the lower oxide film; performing an annealing process using an oxygen gas so that the nitrogen-containing layer is moved on the surface of the lower oxide film, thus

forming a nitride film; forming a upper oxide film on the entire surface to form a dielectric film consisting of the lower oxide film, the nitride film and the upper oxide film; sequentially forming a second polysilicon film, a tungsten silicide film and an anti-reflection film on the entire structure; and patterning the anti-reflection film, the tungsten silicide film, the second polysilicon film and the dielectric film to form a control gate, and then patterning the first polysilicon film and the tunnel oxide film to form a floating gate.--

The paragraph beginning at page 6, line 11 has been replaced with the following paragraph:

--Referring now to Figs. 1B and 2, the wafer in which the tunnel oxide film 103 and the first polysilicon film 104 are formed is loaded into a reaction furnace in which the temperature of 600~700°C and N₂ atmosphere of 10~20ℓ are kept (201 in Fig. 2). After the temperature of the furnace is raised at the N₂ atmosphere of 5~10ℓ to 810~850°C (202 in Fig. 2), a lower oxide film 105 is deposited by means of LPCVD method using DCS and N₂O or NO gas (203 in Fig. 2). At this time, the lower oxide film 105 is deposited in thickness of 35~100Å at the deposition rate of 4~10Å/min. Also, with the temperature of the furnace kept at 810~850°C, introduction of DCS is stopped. Nitrification process by which N₂O or NO gas of 1~20ℓ is introduced for 10~20 minutes is then implemented (204 in Fig. 2). At this time, the thickness of the increasing lower oxide film 105 is about 3~5Å. The reason is that the nitrogen-containing layer 106 is formed below the lower oxide film 105 as the nitrogen concentration distribution shown in Fig. 3A. In other words, the nitrogen-containing layer 106 is formed in thickness of 3~5Å below the lower oxide film 105.--

The paragraph beginning at page 7, line 3 has been replaced with the following paragraph:

--Referring now to Figs. 1C and 2, after the nitrification process, a nitrogen purge process is implemented to raise the temperature of the furnace to 850~950°C under the N₂ atmosphere of 5~10ℓ (205 in Fig. 2). After the temperature within the furnace is raised, an annealing process is implemented by introducing an oxygen gas of about 5~20ℓ for 5~20 minutes (206 in Fig. 2). Thus, the surface of the first polysilicon film **104** is oxidized and the nitrogen-containing layer **106** is therefore moved on a upper side of the lower oxide film **105**, thus forming a nitride film **107**, as shown in Fig. 3B.--

IN THE CLAIMS:

Claims 1-2, 4, 6 and 9 have been amended as follows:

1. (Twice Amended) A method of manufacturing a flash memory device, comprising the steps of:
 - sequentially forming a tunnel oxide film and a first polysilicon film on a semiconductor substrate;
 - etching the first polysilicon film and a first portion region of the tunnel oxide film;
 - forming a lower oxide film on the semiconductor substrate;
 - performing a nitrification process to form a nitrogen-containing layer below the lower oxide film;

performing an annealing process using an oxygen gas so that the nitrogen-containing layer is transferred to a surface of the lower oxide film, thus forming a nitride film;

forming an upper oxide film on the [semiconductor substrate] nitride film to form a dielectric film including the lower oxide film, the nitride film, and the upper oxide film;

sequentially forming a second polysilicon film, a tungsten silicide film, and an anti-reflection film on the semiconductor substrate;

patterning the anti-reflection film, the tungsten silicide film, the second polysilicon film, and the dielectric film to form a control gate; and

patterning the first polysilicon film and the tunnel oxide film to form a floating gate.

2. (Twice Amended) The method according to claim 1, wherein the lower oxide film is formed using [DCS] DiChloroSilane gas and one of N₂O and NO gas at a temperature of 810-850°C.

4. (Twice Amended) The method according to claim 1, wherein the nitrification process is performed by introducing one of N₂O and NO of 1-20ℓ into a furnace at a temperature of 810-850°C for 10-20 minutes, thus forming a nitrogen-containing layer of 3-5Å in thickness in the lower oxide film.

6. (Twice Amended) The method according to claim 1, wherein the upper oxide film is formed using [DCS] DiChloroSilane gas and one of N₂O and NO gas at a temperature of 810-850°C.

9. (Twice Amended) The method according to claim 8, wherein the polysilicon film and the undoped polysilicon film are deposited at a ratio of thickness of 4:1-7:1.

Claim 10 has been newly-added.